National Academies Summer Institute @ West Virginia University 2013

Group VII: Evolution/Ecology
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Teachable Unit: Executive Summary

Title: Mutations in Context

LEARNING OBJECTIVES
General Learning Outcomes (GLOs)

1. Students will explain why and how meiosis results in variation correctly incorporating independent assortment, crossing over and ploidy.
2. Students will explain why and how genetic variation is important for understanding and solving problems in conservation and biodiversity.
3. Students will be able to predict the evolutionary outcomes of mutation events.

Science Content
Students will

- Predict the possible impacts of a mutation during meiosis as an evolutionary event correctly incorporating the following concepts: independent assortment, cross-over, and ploidy and trait variation at the population level.
    - Students will relate meiotic events such as crossing over and independent assortment to genetic variation in a population.
    - Know the phases of meiosis as they apply to chromosomes
    - Know the definitions of crossing-over and independent assortment
    - Calculating the possible combinations of genetic material in humans based on crossing over.
    - Calculating the possible combinations of genetic material in humans based on independent assortment.
- Students will explain the importance of genetic variation in evolution .
- Students will identify the drivers of evolution by natural selection and evaluate them for their importance in conservation.
- Students will predict if a single individual had a mutation by tracing the mutation through

the steps of meiosis.

Science Skills:
Students will be able to:

- Create a graph to show genetic variation including correctly labeling axes.
- Apply Darwin's postulates to explain how natural selection depends on genetic variation.
- Make an argument for why and how conservation of genetic diversity is important for health of populations.
- Evaluate scenarios of life history traits to predict the possible evolutionary outcomes of mutation events.
- Apply knowledge to conservation issues.
- Predict evolutionary outcomes given a mutation in context
- Create visual representation of evolutionary events with diagrams and storyline illustrations.
- Integrate math and biology
- Teach other students about specific factors affecting evolutionary outcomes

TEACHING CHALLENGE

Science Content

Students may be able to recall Darwin's postulates, but often without deep understanding of how those postulates are connected to Mendelian genetics at an organismal level or genetics at a population level.

Students have difficulty bridging changes in scale and building conceptual connections between meiosis, genetic variation, natural selection, and evolution, often viewing these as separate and unconnected processes.

Students believe that all mutations are bad.

Students believe that only survivorship is important for fitness and overlook the importance of reproduction.

BRIEF DESCRIPTION OF TEACHABLE UNIT:

Context

This teachable unit is comprised of student-centered activities and project-centered team based learning that build on student's prior knowledge and addresses major themes and misconceptions about the relationships among meiosis, variation and evolution. Further, this unit will integrate these concepts into a conservation theme. Students are expected to be familiar with the concepts of mutation, inheritance, meiosis, genetic variation and natural selection.

Overall Sequence of activities:

<u>Class 1:</u> (GLO1, Knowledge)

Prior to class, students will draw the process of meiosis indicating crossing over and recombination events.

Set up: Class discussion about how meiosis contributes to genetic diversity.

Activity : Students will apply ideas from the homework and class discussion on meiosis by considering a genetic mutation in the germline of one individual. Teams of students will draw a cartoon diagram reflecting a mating event between a wild-type and the mutant individual with 2N=8. The diagram should show an outcome where the mutation is inherited and there is positive selection for this mutation in the environment. Cards are redistributed to other groups for peer evaluation and feedback. A Socratic dialogue about the relationship between the meiotic process just diagrammed and genetic variation follows.

Assessment:

Formative: Students will answer clicker questions about correct and incorrect representations of various stages of meiosis.

Class 2: (GLO3, Knowledge, Comprehension, Application, Evaluation)

Activity : Students will brainstorm and share ideas about additional information (e.g. life history traits related to fitness) that is needed to answer the basic question "What are the potential evolutionary outcomes of a heritable mutation that extends the lifespan of an individual?" The group will explicitly discuss "evolutionary outcome."

Jigsaw activity: Groups of 4-5 students will discuss one of the categories of information developed in the previous activity and become "experts" on how different scenarios within that category might affect evolutionary outcomes. If there are multiple teams with the same category, these teams will consult each other to confirm understanding. The instructor will check-in with these groups to confirm understanding. Students will then form new groups that include at least one member who is an expert in each category. Students will teach each other in these new groups about their category. As a group, students will then discuss how the categories interact to produce different evolutionary outcomes. Instructor will then ask for students to call out key terms they used to get students to start thinking about the terminology to incorporate into their new framework

Assessments:

Formative:

- Brainstorm results
- "Expert" check-in
- One minute paper on the role of reproduction in determining the evolutionary outcome of a mutation as a formative assessment (at the end of class). The information from this assessment will be used as a discussion point in the following class meeting.

Summative:

- Exam questions - predictions of evolutionary outcomes
- Student teams will generate two scenarios combining 3 life history traits that result in two of three different evolutionary outcomes (mutation will fix at 100% frequency in the population, mutation will fix at 0% frequency in the population, mutation will drift in frequency in the population) and provide the reasoning behind these outcomes, to be turned in at the beginning of the next class.
- Resource: software allowing students to predict evolutionary outcomes:

http://www2.cedarcrest.edu/academic/bio/rkliman/rmk_evolgenius.shtml

Class 3: (GLO: 1, 3 Blooms: Knowledge, Comprehension, Application, Evaluation)

Activity : Students will be shown a slide of some organism, real or fictional, that includes several groups of parents and their offspring. They will then be asked to consider the question, "Do these organisms show evidence for evolution"? Students will respond "yes" or "no" with clickers, discuss with neighbors, and revote. After soliciting student clarifications and responses, a mini-lecture or Socratic dialogue will follow to reinforce understanding of the biological processes that generate variability in populations (meiosis), the relationship between phenotypic and genotypic ratios (Mendelian genetics), and changes in gene frequencies in populations (population genetics).

Assessment:

Formative: Clicker question (think)-Pair-Share (Socratic Discussion)

Summative: To integrate class 3 focusing on specific examples of adaptations in populations with previous lessons on connecting mutation to evolution, students will draw a cartoon diagram representing a genetic mutation in the germline of one individual in a population, meiosis in individual with mutation, a mating event between a wild-type and a mutant individual showing one outcome where the mutation is inherited, and selection for this mutation in the environment. Groups will present the cartoon of another group to the class with doc-cam with feedback and discussion.

Class 4: (GLO: 1,2,3 Bloom's: Knowledge, Comprehension, Application, Evaluation)

Set-up: Students will review material about mutations and evolutionary consequences from the previous session.

Activity: Students will form groups of 4 and, as a group, choose a species of interest. Students will research the basic natural history of the organism and pick a trait that is variable in the species. The students are then given a series of frequency distributions, to which they label with their chosen trait. The instructor then picks a perturbation example from a hat. Each group then discusses and draws how that perturbation impacts the species in relation to the variable trait for each frequency distribution. After discussion, the groups share with the class. A second perturbation is then chosen, drawn/discussed, and shared.

Assessment:

Formative:

- Graphs drawn during class are turned in.
- Teams will draw a concept map linking meiosis, genetic variation, natural selection, fitness, Darwin's postulates, species, conservation, ploidy.

Summative: exam questions that use a new perturbation/ new impacts.

HOW DOES THIS TEACHABLE UNIT ADDRESS THE FOLLOWING THEMES?

Diversity

This evolution and ecology unit addresses diversity in a number of ways. 1) The topics of

mutation, variability and conservation are applicable to a variety of students. In studying conservation, students from various regions are able to address local environmental and ecological concerns in which they are familiar with to their research projects. 2) Permanent teams are established at the beginning of the semester to ensure heterogeneous groups with respect to academic performance, race, gender, and social interests. This will allow for a variety of backgrounds and ethnicities to be represented during team-based activities, which will increase the richness of ideas and creativity within the group. 3) Multiple activities include individual work and brainstorming. Part of the intent with this is to relax and reassure any introverts in the classroom.

Active learning

Students will buy into this unit because it connects common topics of meiosis, variation and natural selection to conservation. Students will engage in active learning through team discussions and student-student teaching about the perpetuation of genetic variation through meiosis and mutation, and about the relationship of genetic variation to natural selection. In teams, students will work together to explore the impact of mutation and genetic variation in general to an issue in conservation.

<u>In Practice:</u>

Brainstorming
Group problem solving
One-minute paper
Concept mapping